

PREFACE

This book grew out of the notes I developed for my graduate course entitled Advanced Petrophysics at the University of Texas at Austin. The course was designed to provide a quick-paced introduction to petrophysics to first-year MS and PhD students in the Department of Petroleum and Geosystems Engineering and at the same time cover a number of advanced topics in the subject. The students came with varied backgrounds in petroleum engineering, geological engineering, chemical engineering, mechanical engineering, civil engineering, electrical engineering, physics, mathematics, geology, and geophysics. The makeup of the class in any one semester typically consisted of 30% of students with petroleum engineering degrees and 70% with degrees from other disciplines. Teaching a graduate course to students with such a wide range of backgrounds was very challenging and as is common in petroleum engineering, there was no suitable textbook for the course. Therefore, I decided to write one.

Chapter 1 is designed to introduce geological concepts and set the stage for the material to come. This material is for self study as I usually do not cover it in class. Chapter 2 covers porosity and water saturation, the two petrophysical properties that play a role in reserve estimation. The section on well logs is included for self study as most petrophysical properties of reservoirs are usually obtained from well log analysis. The material in this section is a summary of information typically found in handbooks from well logging service companies except the section on NMR principles, which is based on information from my original research. Chapter 3 addresses absolute permeability and permeability anisotropy for single-phase flow in porous media. Chapter 4 discusses the subject of heterogeneity and introduces the basics of geostatistics for coping with the estimation of petrophysical properties in heterogeneous reservoirs. Chapter 5 deals with dispersion in porous media. In this chapter, I have followed the old adage that a picture is worth more than a thousand words. Therefore, I have used images of fluids in porous media from my research to visualize dispersion in porous media. Chapter 6 deals with interfacial phenomena and wettability and forms the introduction to multiphase systems. Chapter 7 deals with capillarity and capillary pressure, a fascinating subject that is sometimes difficult to understand. For this reason, I have devoted quite a bit of space to this subject and as a result, Chapter 7 is the longest chapter in the book. Chapter 8 concludes the book with a look at effective and relative permeability for multiphase

flow in porous media. Appendix A outlines my fail-proof method for dimensional analysis, a subject that I feel every engineer should master and apply in his or her professional practice. Appendix B gives a series of projects that I have designed to enable the reader to apply the principles learned in the book to build a petrophysical model using well logs and core data from a major petroleum-producing province. The projects should be performed in the sequence presented and will culminate in reserve estimation with uncertainty included.

I have included over 140 end-of-chapter exercises to provide opportunity to strengthen the learning outcome and to extend some of the ideas presented in the book. I have prepared a solution manual as a companion volume to this book in the hope that students, faculty members, and other readers will find it helpful in learning the subject.

The book does not address all the topics in petrophysics as it was not intended as a compilation of all that can be said about the subject. Rather, it was written for a one-semester course and as a result I had to select a limited number of topics to cover in one semester. However, after writing it, it has become too large for a one-semester course. I typically cover Chapters 2, 3, 6, 7, and 8 in that order. If time permits, I then cover Chapters 4 and 5. With over 750 single-spaced pages, the book also has become too large to be published in one volume. Therefore, the book is published as a 3-volume set. Volume 1 consists of Chapters 1 through 4. Volume 2 consists of Chapters 5 through 8. Volume 3 is the solution manual for the end-of-chapter exercises.

I wrote the first draft of the book in fall 2006 and made the first electronic version available to the students in my course in fall of 2007. Regrettably, contrary to my instructions, an unknown student posted the draft on the Internet for free downloads. It has since been brought to my attention that the rough draft has been translated into Farsi without my permission and is widely circulated in Iran. That draft is too rough and does not contain the exercises and the worked examples of this finished product. It should be discarded.

I have used material from the book to teach continuing education courses for petroleum exploration and production companies over the years. I have used the material to teach courses for Shell Petroleum Development Company in 1999, Mobil Producing Nigeria in 2000, and Petrobras in 2006, 2008, and 2010. I have also used the book to teach graduate courses at the University of Trinidad and Tobago

and at the African University of Science and Technology. All have found the material useful and instructive.

I acknowledge with gratitude the assistance I received from my colleagues in the preparation of this book. Professors Larry W. Lake and Russell T. Johns read all 8 chapters and made valuable suggestions for improvements. Professor Sanjay Srinivasan read Chapter 4 and suggested improvements in the sections on geostatistics. Any error or mistake in the book is mine and should in no way reflect on my colleagues. My colleague, Professor Carlos Torres-Verdin, provided the data set for the projects in Appendix B for which I am grateful. I acknowledge the assistance of Mary

C. Pettengill, our librarian, in tracking down the technical papers that I needed to read in the preparation of this book, even papers written in 1717 on capillarity. Finally, I thank the 640 graduate students who have taken my Advanced Petrophysics course at the University of Texas at Austin over the years, some of whom wished I could make the material in this book more widely available to the petroleum engineering community. With the publication of this book, your wishes have now been fulfilled.

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